FRIB Introduction and FRIB Controls

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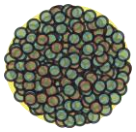
MICHIGAN STATE UNIVERSITY

U.S. DEPARTMENT OF ENERGY | Office of Science

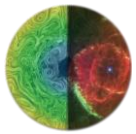
This material is based upon work supported by the U.S. Department of Energy Office of Science under Cooperative Agreement DE-SC0000661.
Michigan State University designs and establishes FRIB as a DOE Office of Science National User Facility in support of the mission of the Office of Nuclear Physics.

FRIB – a DOE-SC National User Facility Enabling Scientists to Make Discoveries



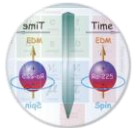
Properties of nucleonic matter

- Classical domain of nuclear science
- Many-body quantum problem: intellectual overlap to mesoscopic science – how to understand the world from simple building blocks



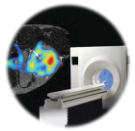
Nuclear processes in the universe

- Energy generation in stars, (explosive) nucleo-synthesis
- Properties of neutron stars,
  EOS of asymmetric nuclear matter



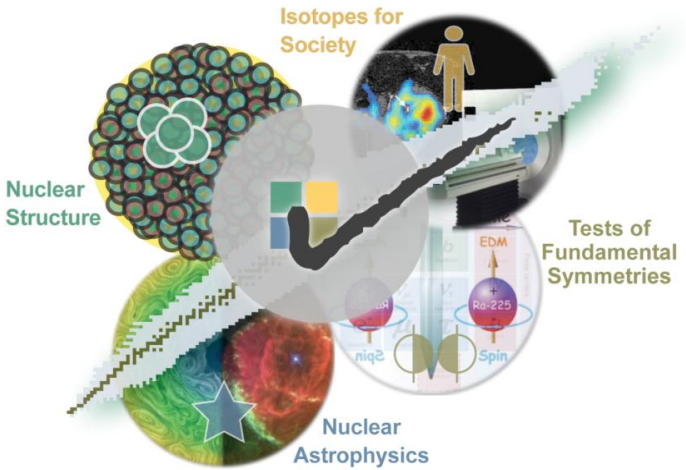
Tests of fundamental symmetries

- Effects of symmetry violations are amplified in certain nuclei



Societal applications and benefits

- Bio-medicine, energy, material sciences, national security



FRIB Users Organization
Over 1250 Users Ready for Science

- Users are organized as part of the independent FRIB Users Organization
  - FRIBUO has 1268 members (92 US Colleges and Universities, 10 National Laboratories, 58 countries) as of 2 October 2012
  - Chartered organization with an elected executive committee (Chair is Michael Smith, ORNL)
  - FRIBUO has 20 working groups on experimental equipment
  - 41 members from 21 states visited Capital Hill on 5 March 2012
- Science Advisory Committee
  - Review of equipment initiatives (Feb. 2011)
  - Review of FRIB Integrated Design (March 2012)

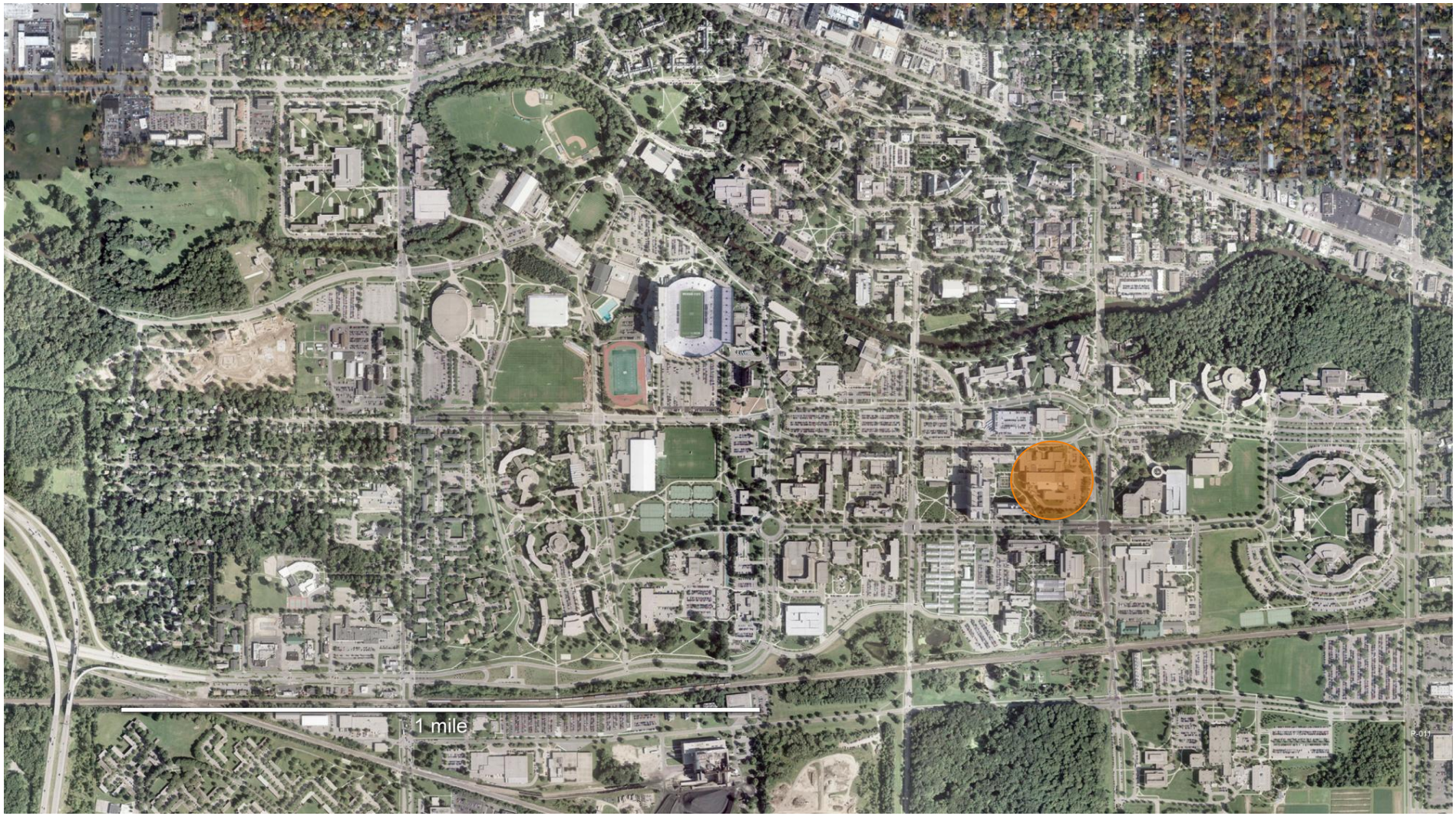
August 2011
Joint Users Meeting
284 participants

fribusers.org

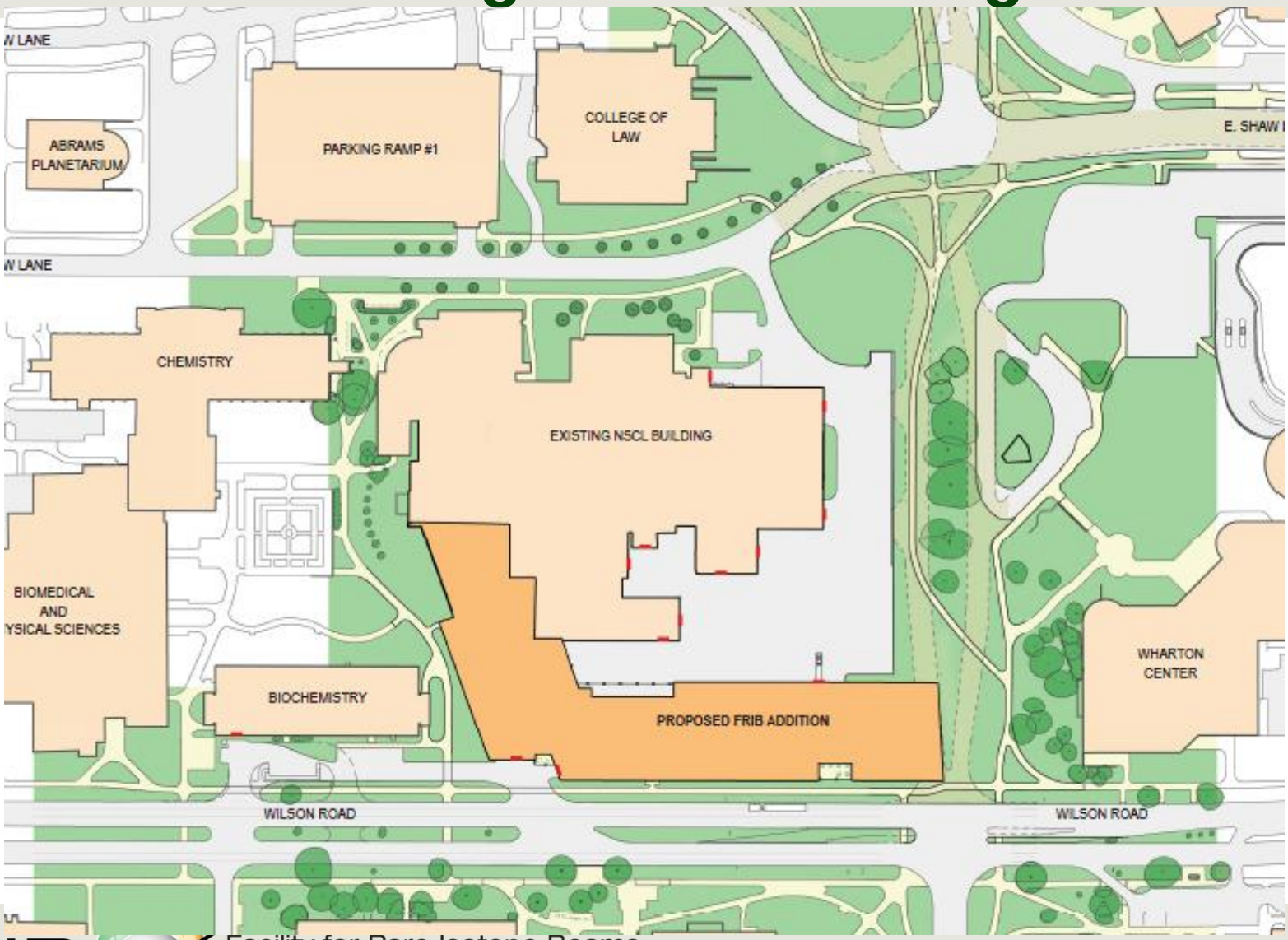
FRIB Project at MSU
Project of $680M ($585.5M DOE, $94.5M MSU)

- Dec. 2008: DOE selects MSU to establish FRIB
- June 2009: DOE and MSU sign corresponding cooperative agreement
- Sept. 2010: CD-1 granted; conceptual design complete & preferred alternatives decided
- April 2012: Lehman Review, readiness to baseline

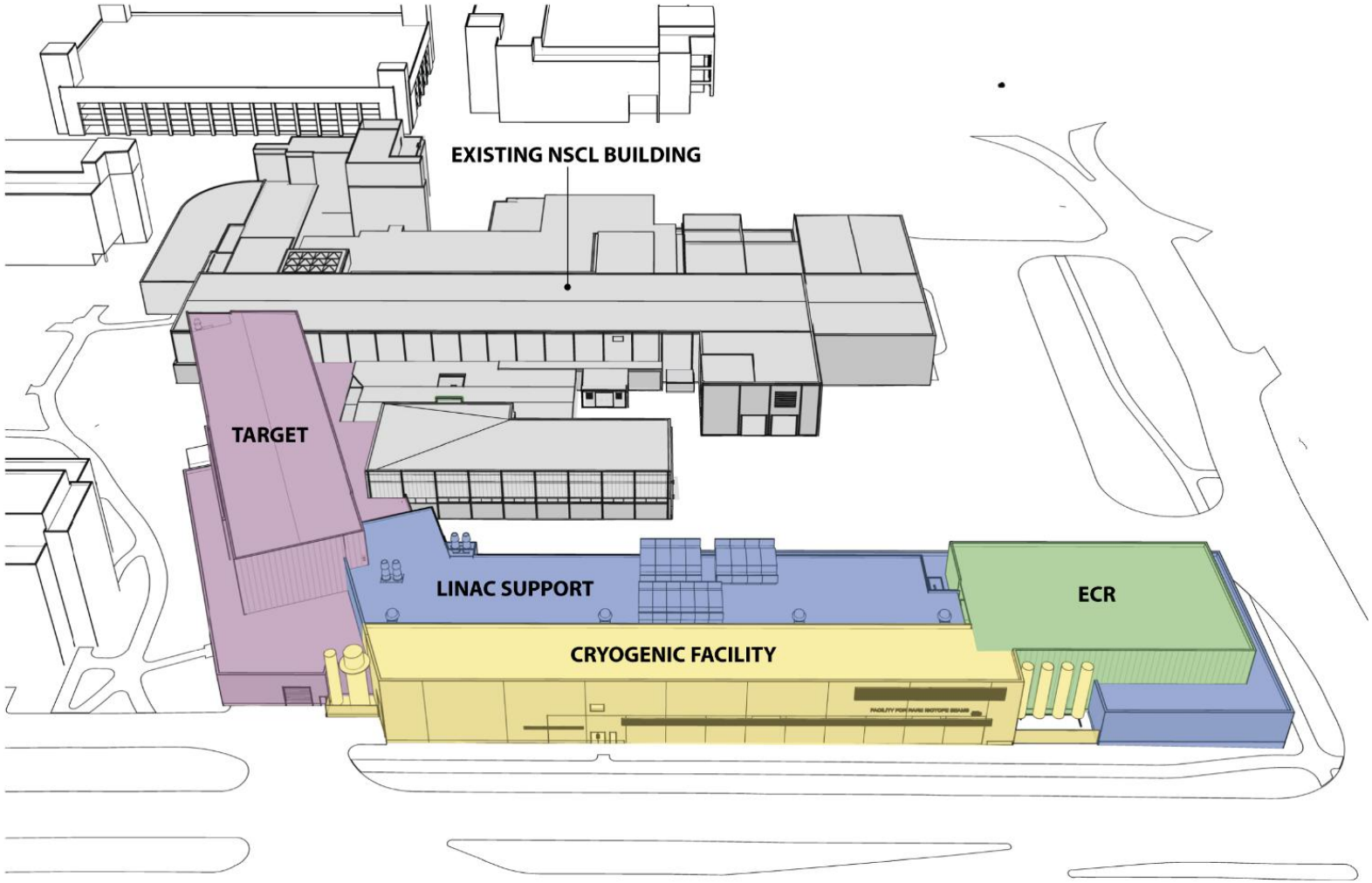
Michigan State University
57,000 people; 36 sq mi; $1.8B annual revenue; 552 buildings



Site Layout: FRIB addition connects to existing NSCL building



Building Configuration



Final Design of Conventional Facilities Complete

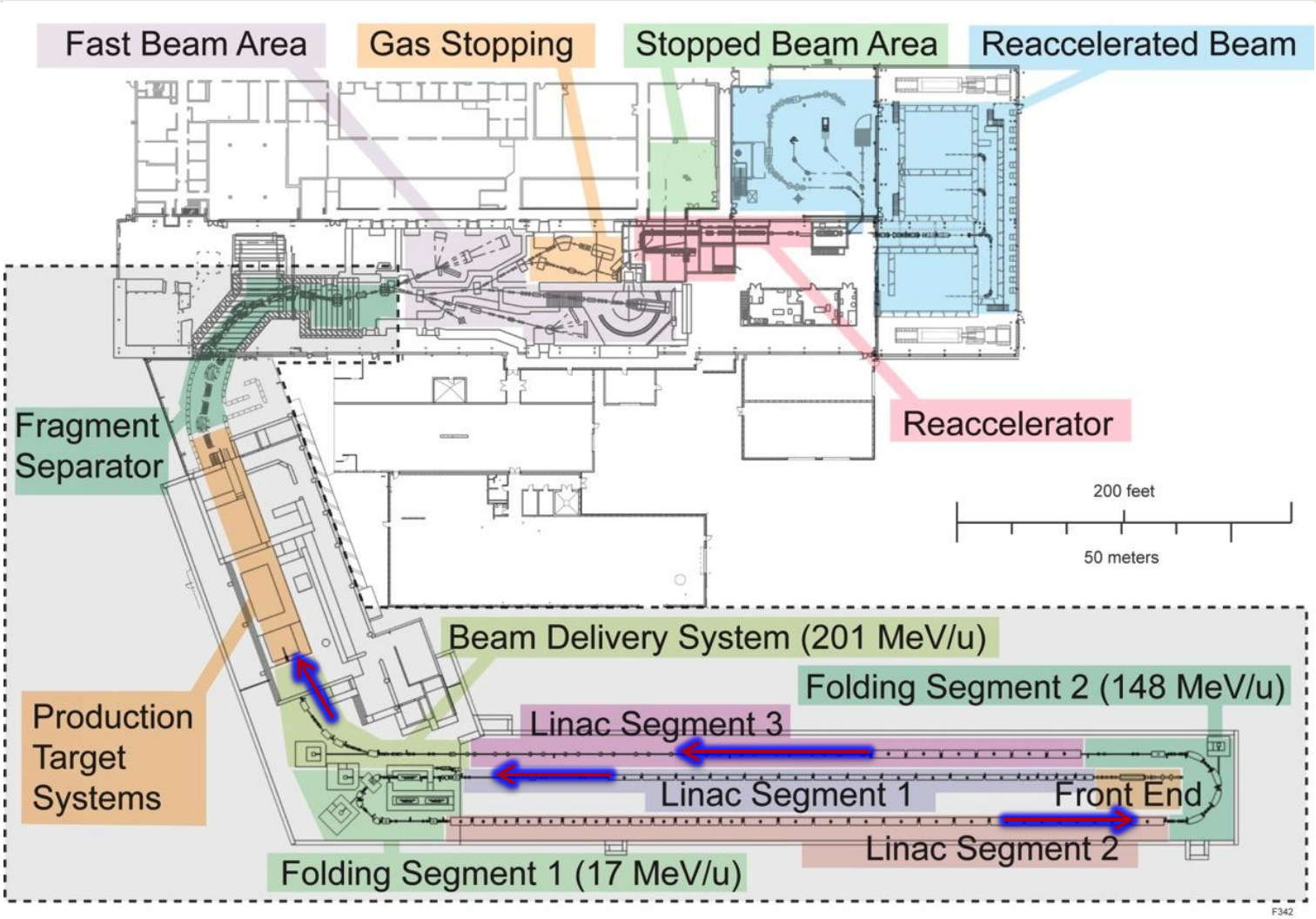
View from Southeast

Ready for Civil Construction to Begin

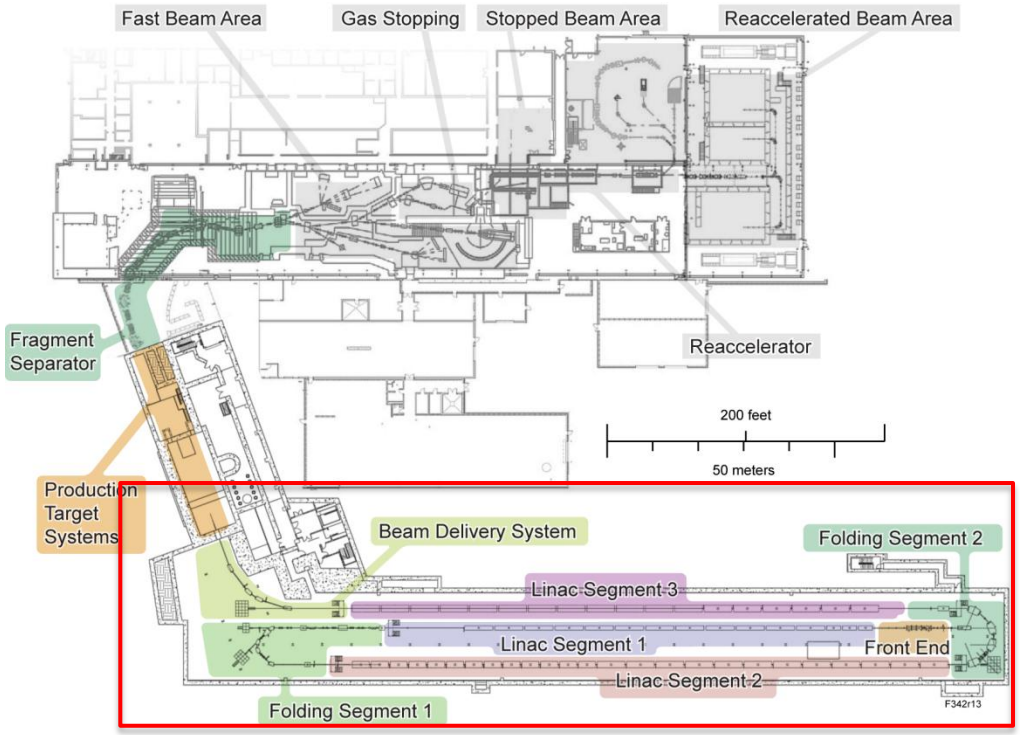
- Site preparation activities complete; pilings for earth retention system being installed as long-lead procurement

Web cams at www.frib.msu.edu

Facility Layout



Accelerator Design & Requirements

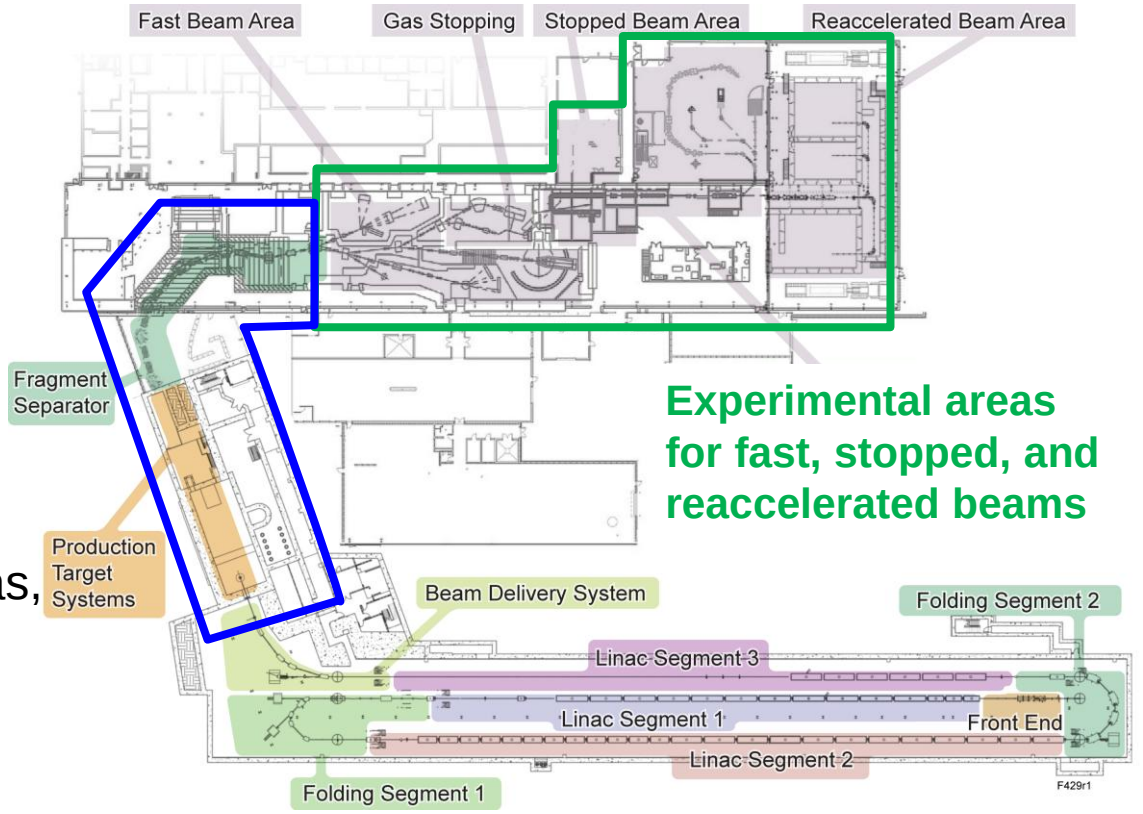


- Delivers FRIB accelerator as part of a DOE-SC national user facility with high reliability & availability
- Accelerate ion species up to ^{238}U with energies of no less than 200 MeV/u
- Provide beam power up to 400 kW
- Satisfy beam-on-target requirements

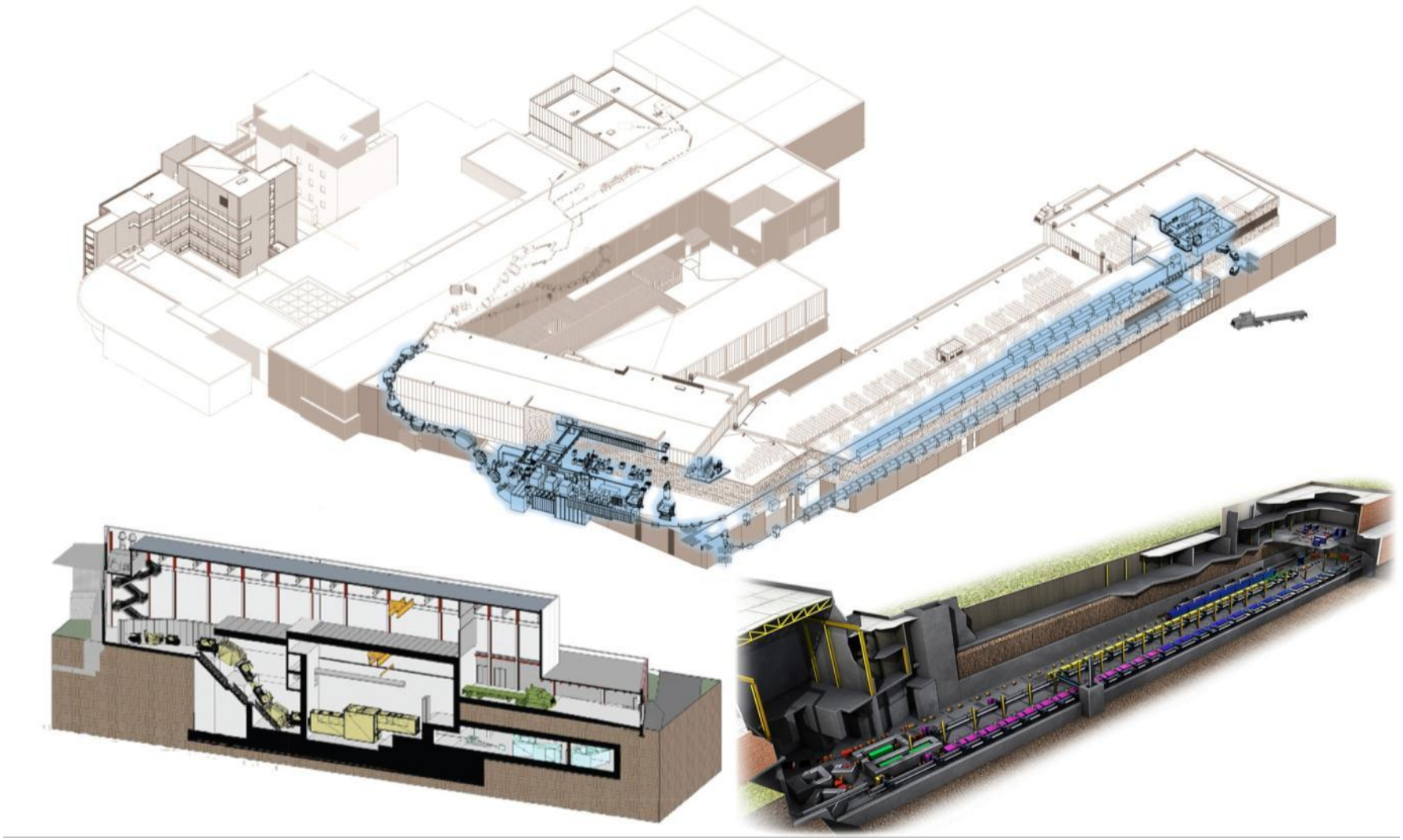
- Energy upgrade by filling vacant slots with 12 SRF cryomodules
- Maintain ISOL option
- Upgradable to multiuser simultaneous operation of light/heavy ions with addition of a light-ion injector

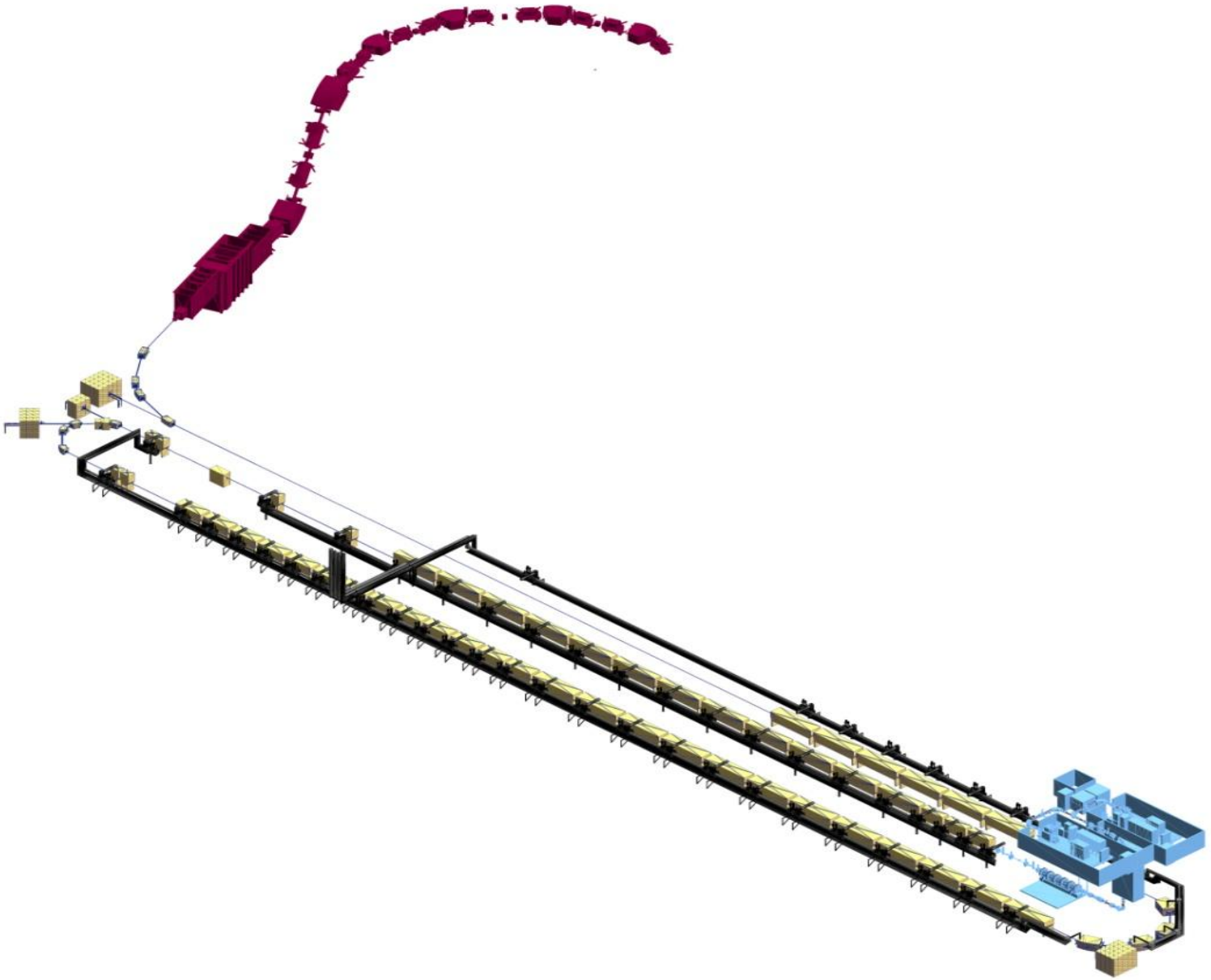
Experimental Systems Scope Defined and Unchanged since April

- Facility performance expectations
  - Rare isotope production with primary beams up to 400 kW, 200 MeV/u uranium
  - Fast, stopped and reaccelerated beam capability
  - Experimental areas and scientific instrumentation for fast, stopped, and reaccelerated beams
  - World-class science on day one
- Experimental Systems project scope
  - Production target facility
  - Fragment separator
- Non-TPC contributions to Experimental Systems
  - Beam stopping systems, reaccelerator, experimental areas, experimental equipment

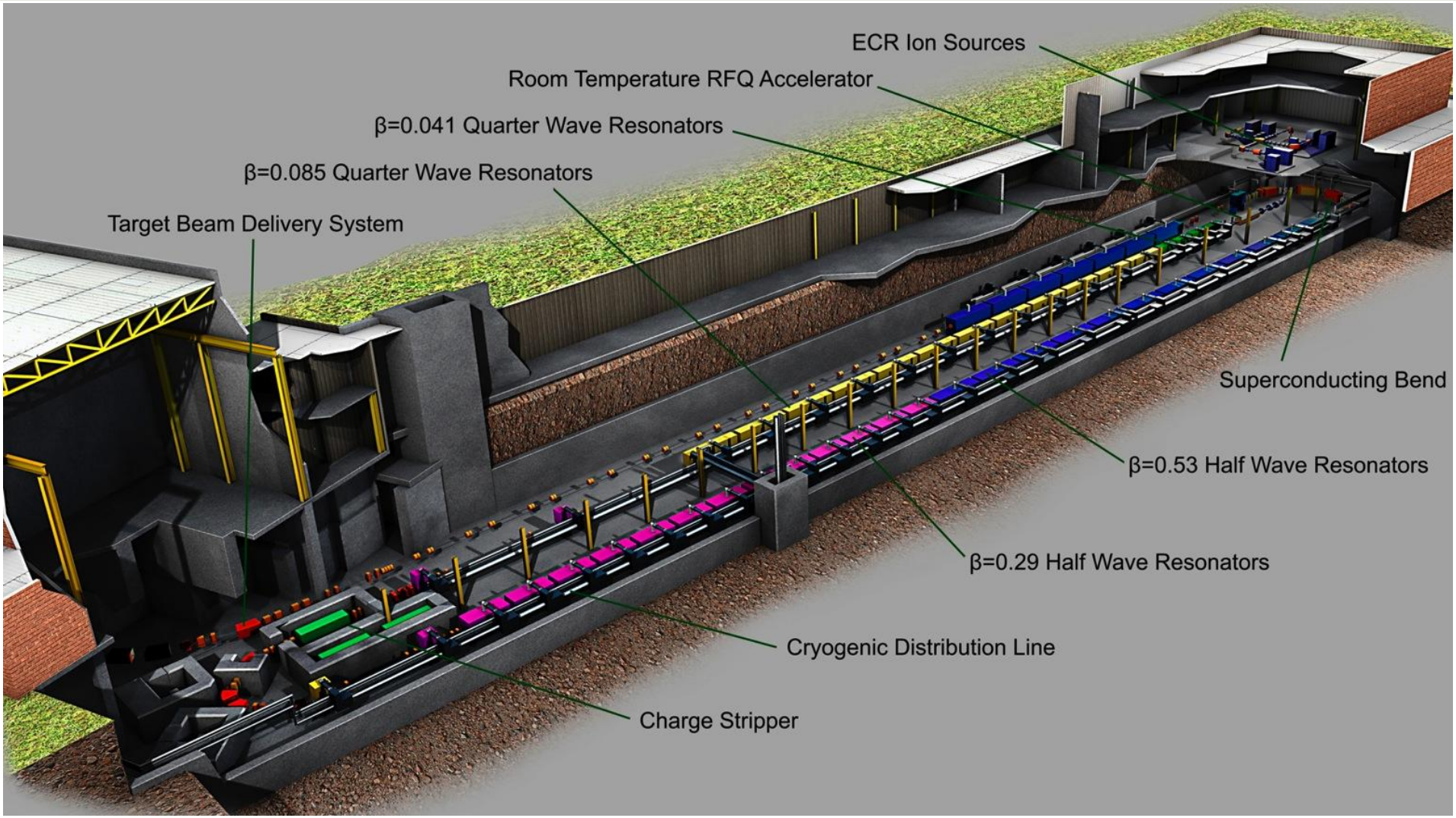


Facility Layout



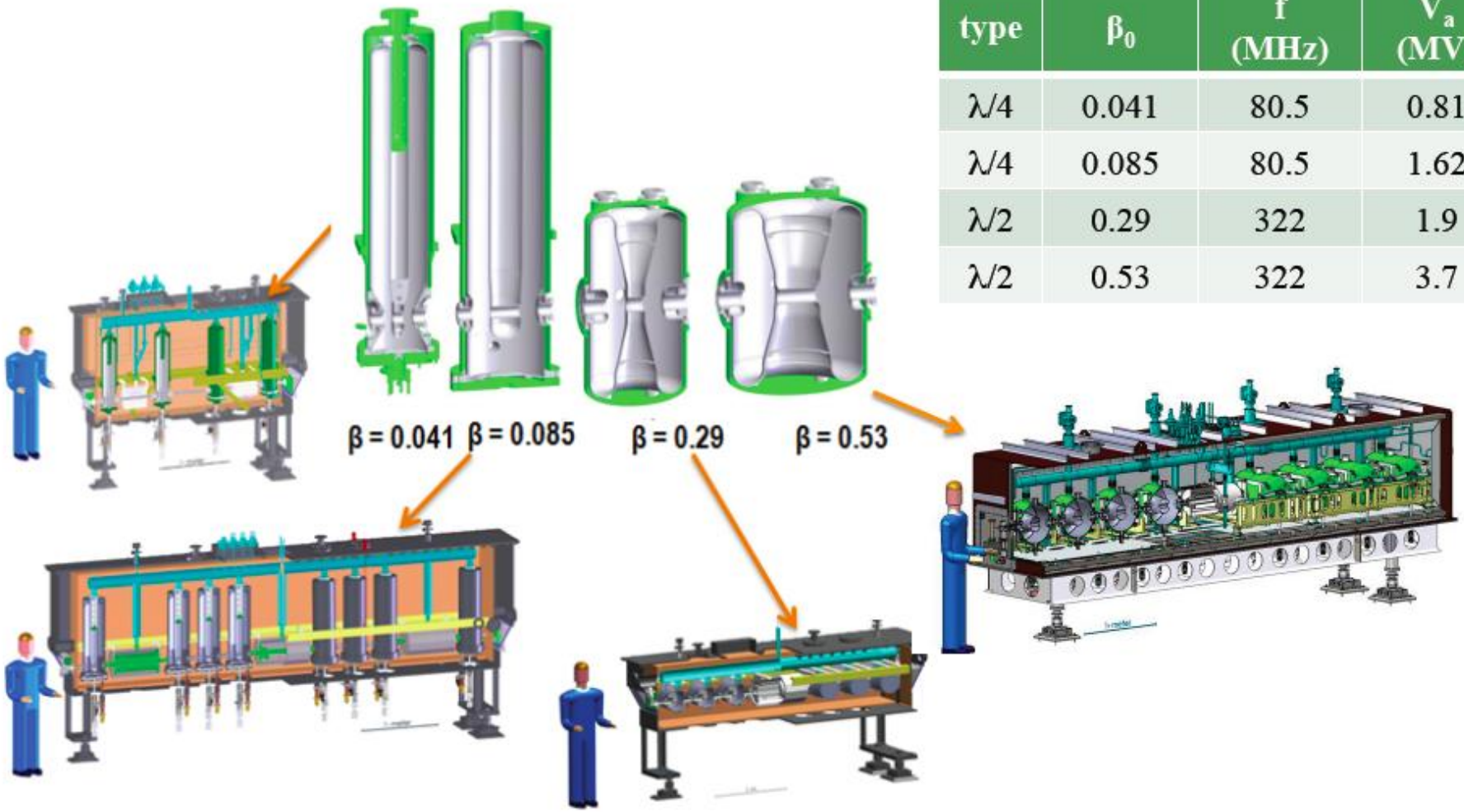


FRIB Driver Accelerator Layout



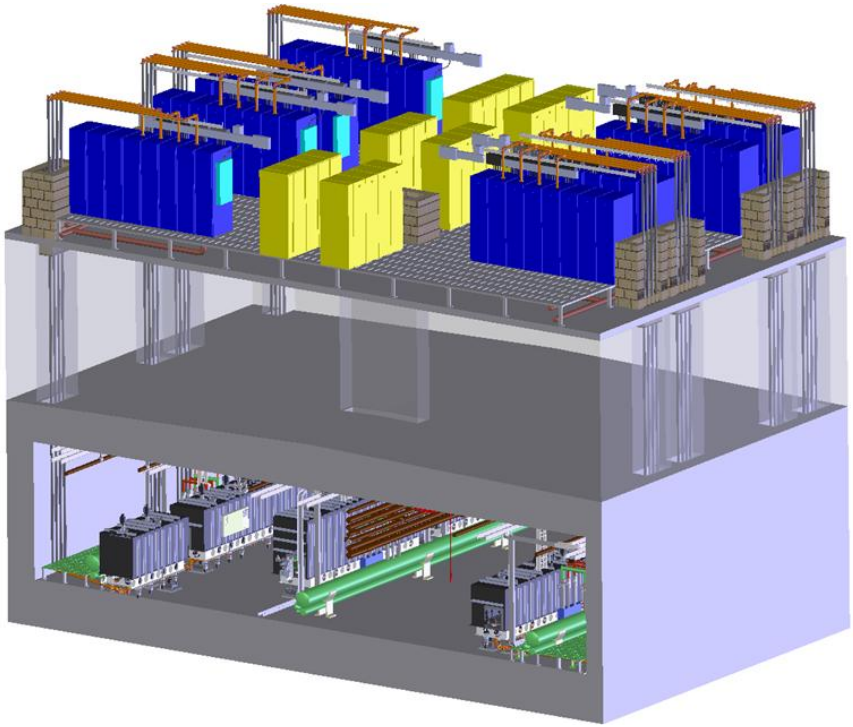
FRIB Resonators and Cryomodules: Beam Dynamics Specifications

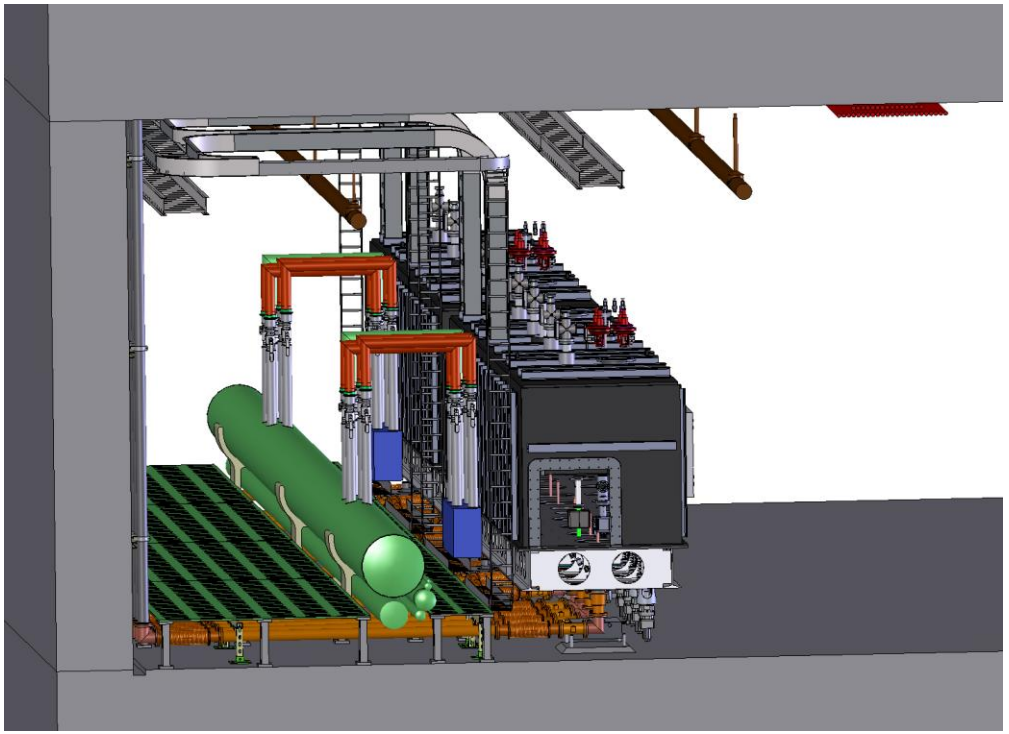
type	β_0	f (MHz)	V_a (MV)
λ/4	0.041	80.5	0.81
λ/4	0.085	80.5	1.62
λ/2	0.29	322	1.9
λ/2	0.53	322	3.7



Conventional Facility

- Racks, cable tray, conduit arrangement
- How does tunnel look like





Target Building

Controls Technical Scope

- Global systems
  - Global timing system
  - Machine protection system
  - Network and computers
- High level applications
  - Database
  - High level applications
    - »Console application
    - »Web application
  - Physics applications
- Low level controls
  - »Vacuum/Power Supply/RF
  - »Cryomodule & Cryoplant
  - »Front End/Ion Source/RFQ
  - »Stripper
- Personnel protection system
- Diagnostics support
- Conventional facility integration

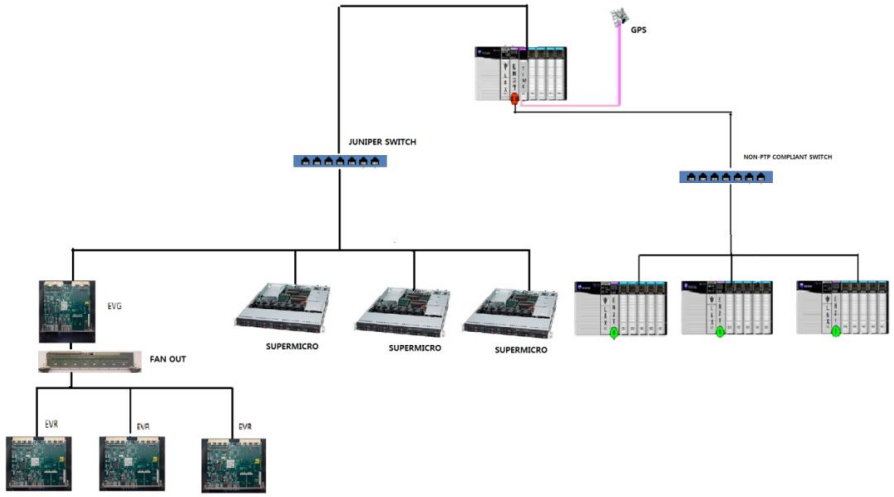
Controls Scope Requirements Defined

- An integrated control system
  - Technically Integrated
  - No fence between ASD and ESD
- A large distributed control system based on EPICS framework
- User interfaces/tools with consistent look and feel
  - Remote supervisory control and data acquisition of devices/detectors
  - Integrated control room toolkit (e.g. snapshot/restore, alarm handler)
  - Integrated physics applications and model-based beam control
- Low level device control and process control
  - PLC, IOC and instrumentation
- 35 μs machine protection mitigation (10μs for MPS electronics)
- Global timing system distributes trigger, timestamp and real-time information facility-wide
- High-bandwidth/reliability network and computing platform to support control system operation
- Personnel Protection System to ensure safe operation
- Diagnostics high speed data acquisition
- High availability and long lifetime as a user facility

Control System Scale

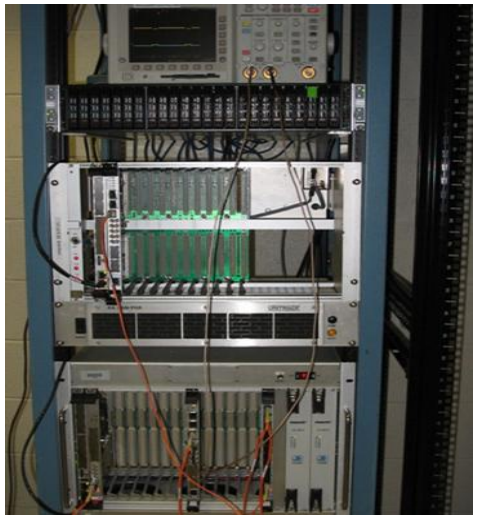
- It is a large scale distributed control system
  - ~200m * 200m physical distribution
  - ~150 Computers/EPICS Input/Output Controllers (IOC)
  - ~100 Programmable Logic Controllers (PLC)
  - Thousands of network attached intelligent devices
    - » RF controller
    - » Power supply controller
    - » Vacuum gauge/pump controller
    - » Programmable logic controller
  - ~ 3000 network ports
  - >500 timing drop points
  - ~2000 MPS fast protection inputs
  - ~750 racks and more than 100 with controls devices

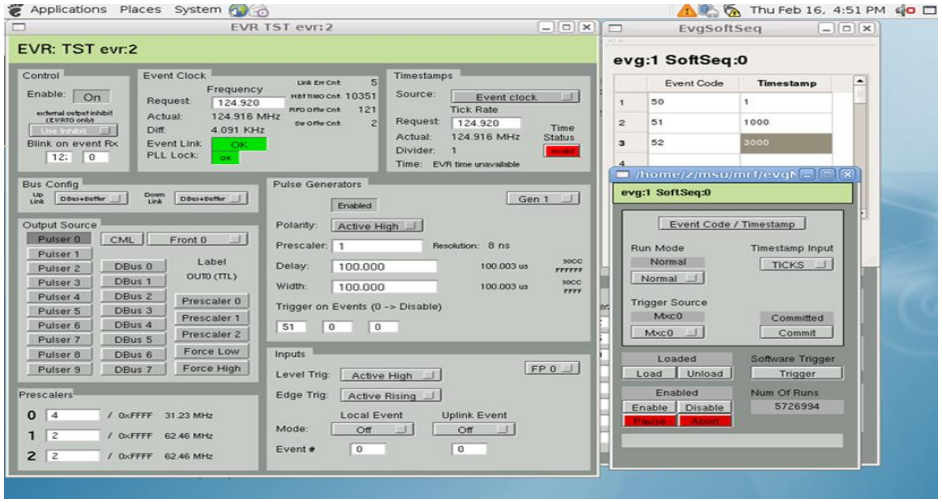
EVG/EVR + PTP

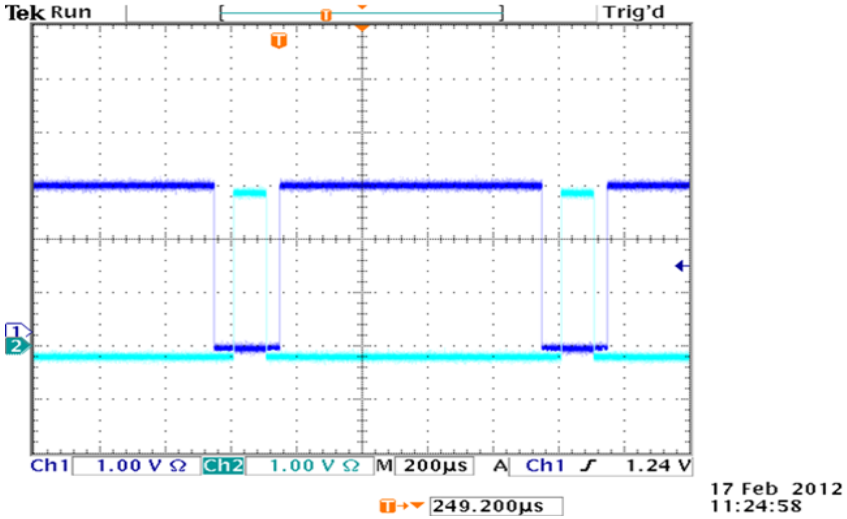


- PLC HIPROM module works
- Deploy with 900W project
- Looking for a PMC module for EVG to simplify the effort

EVG/EVR test platform works

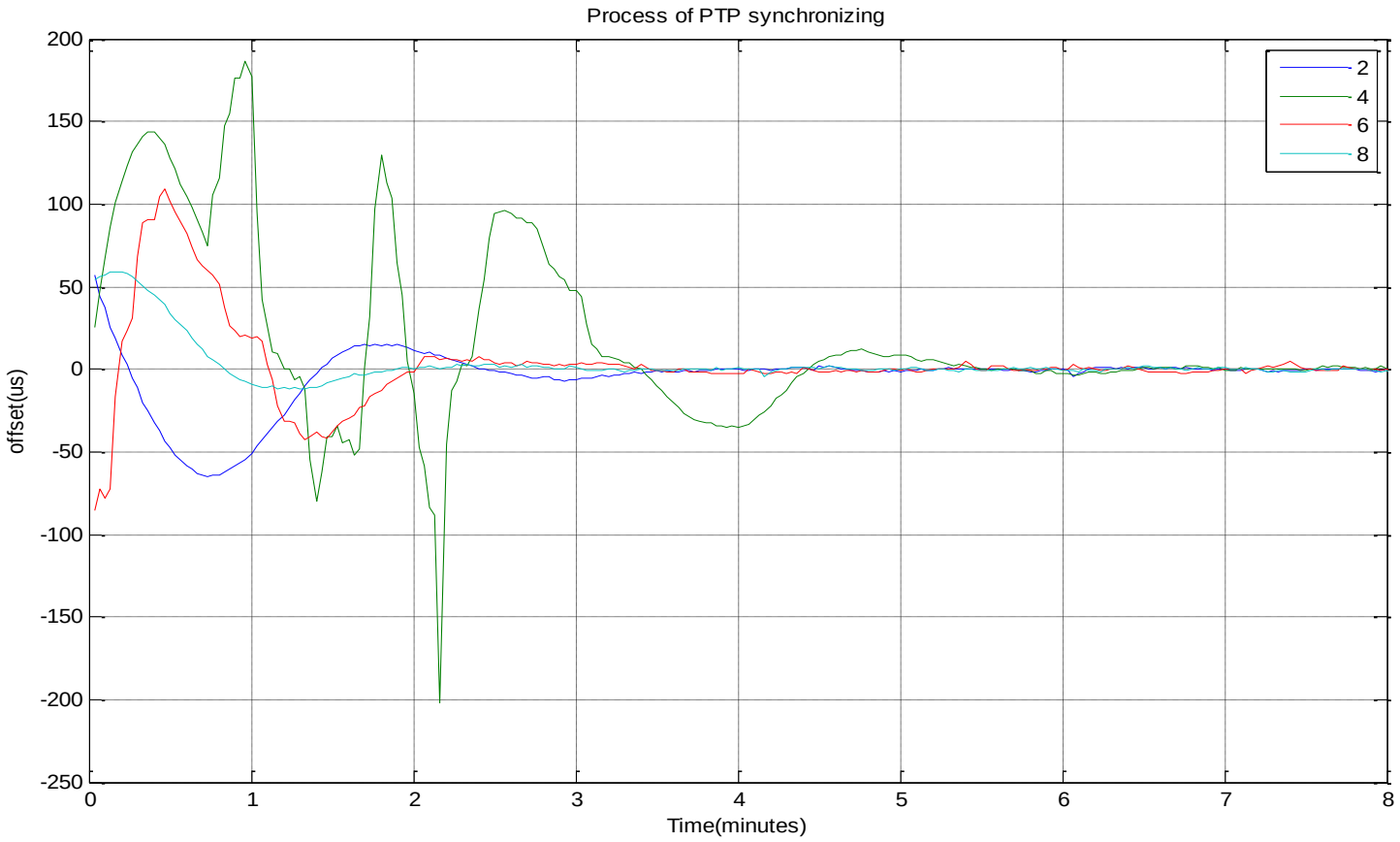




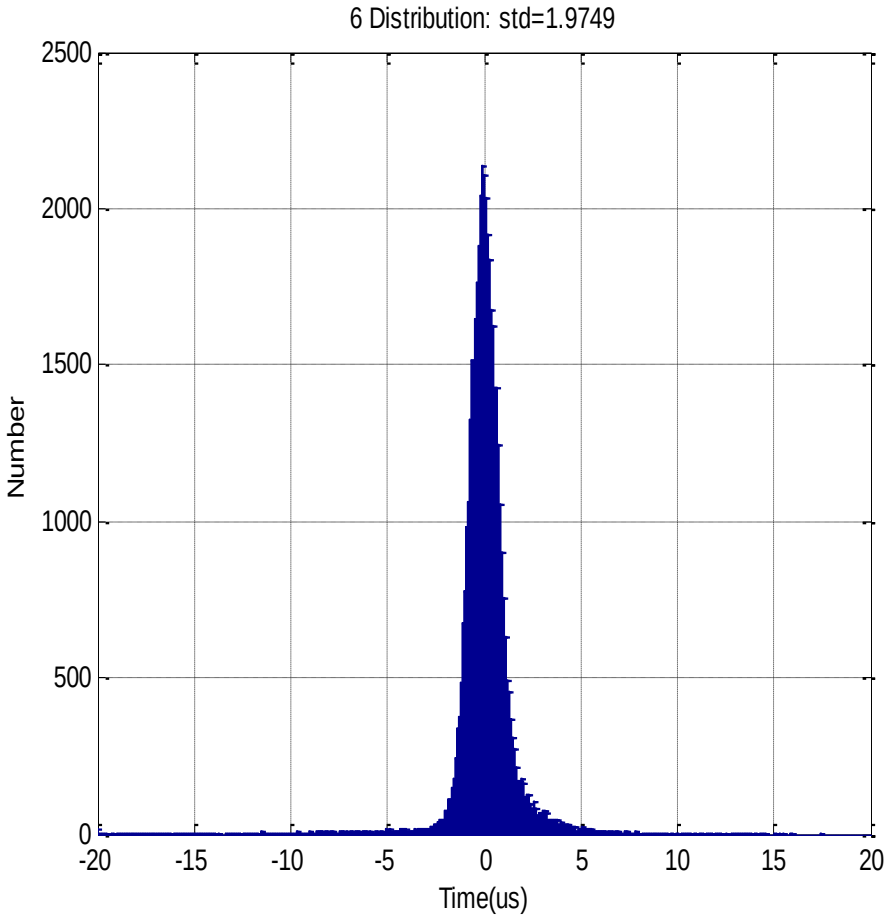


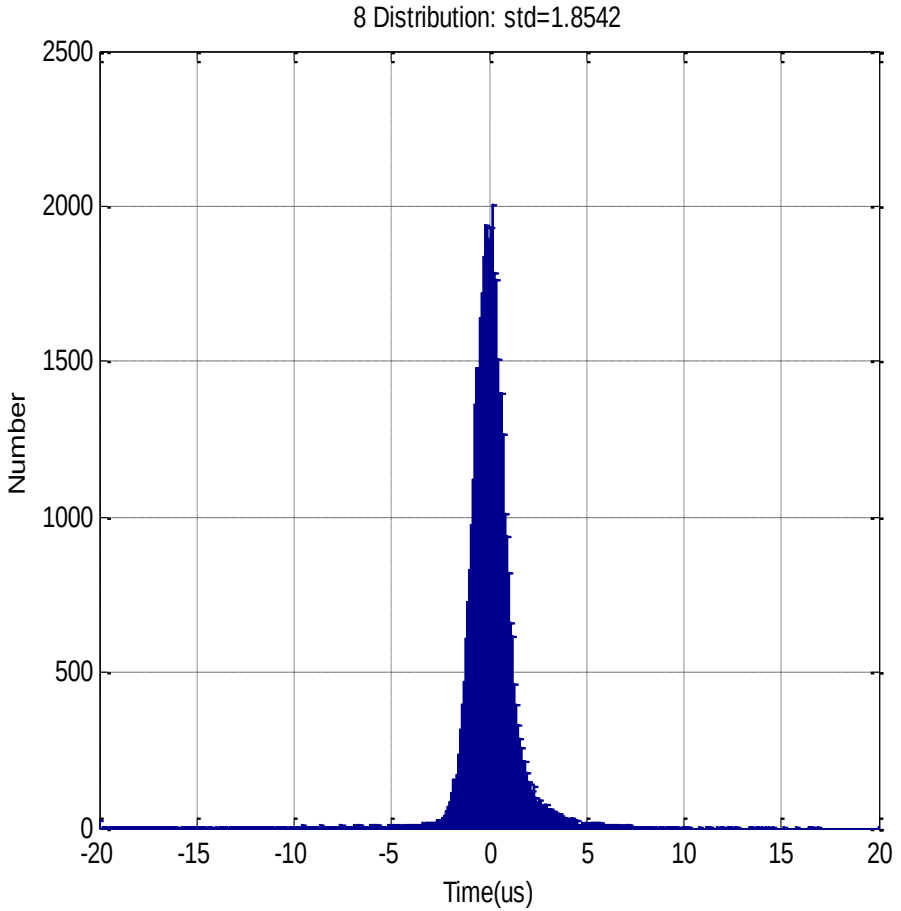
Convergence process, PTP looks great

- Testing result : T_{offset} : master and slave time offset

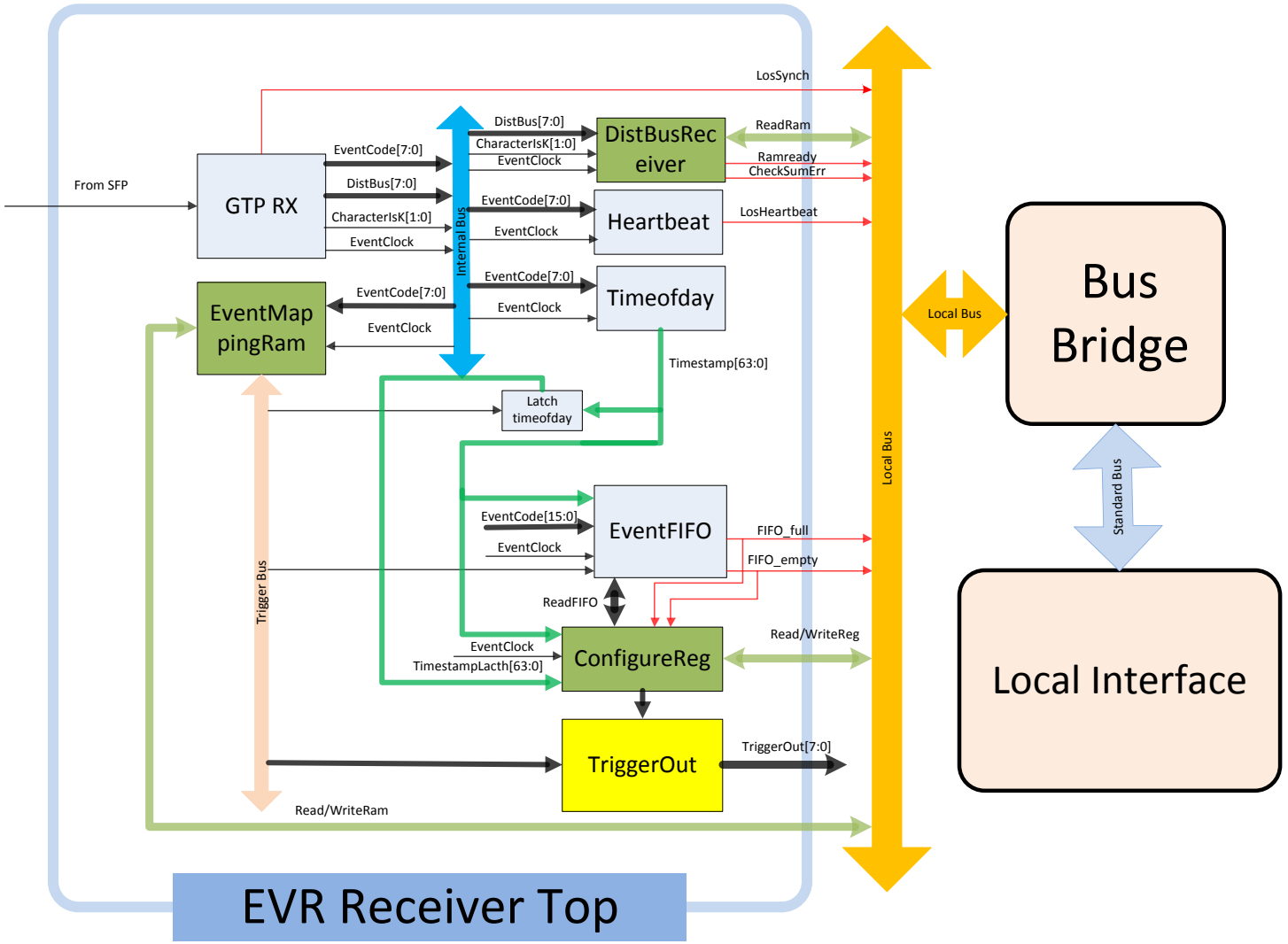


6 nodes & 8 nodes Histogram

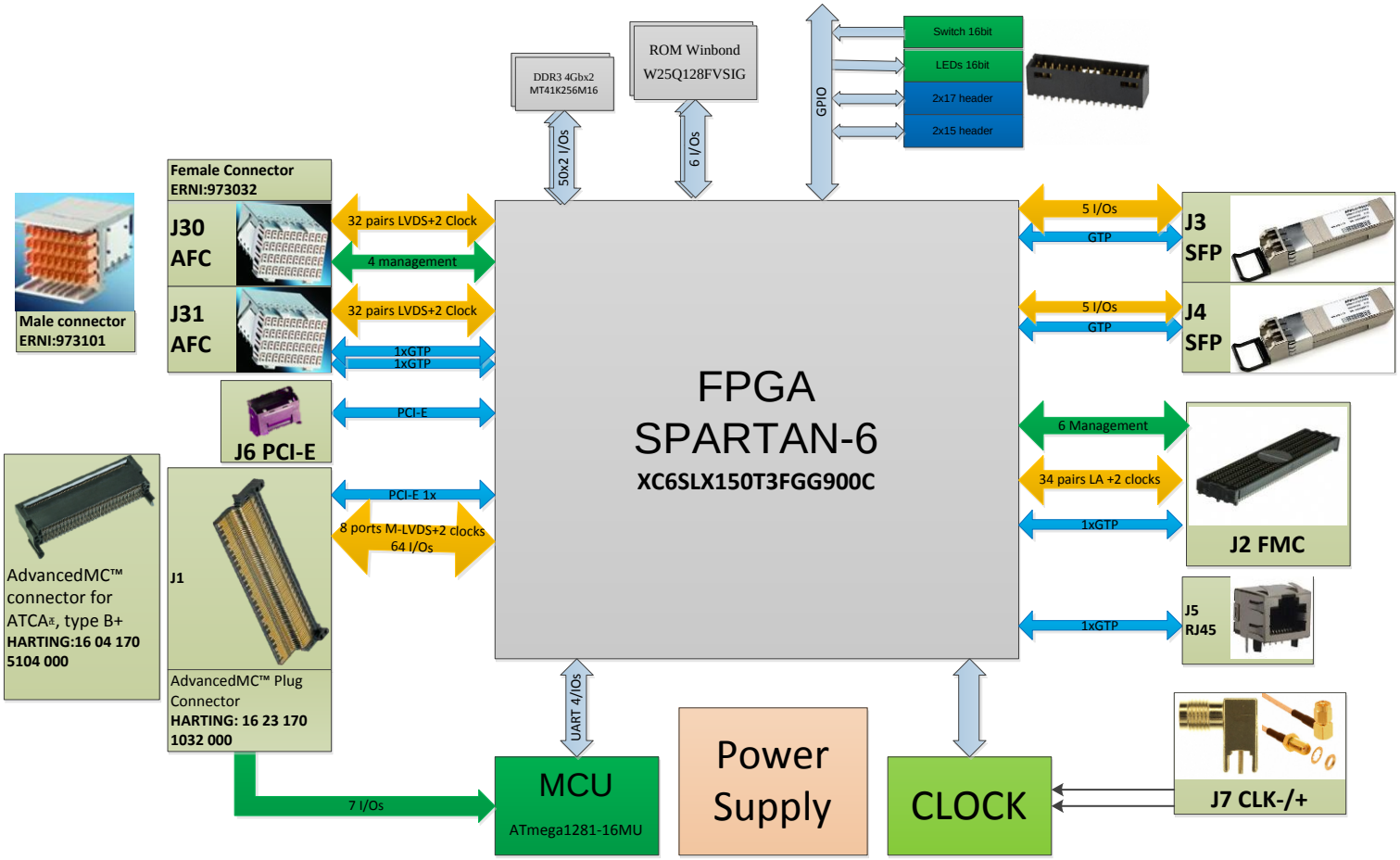




EVR core requirement

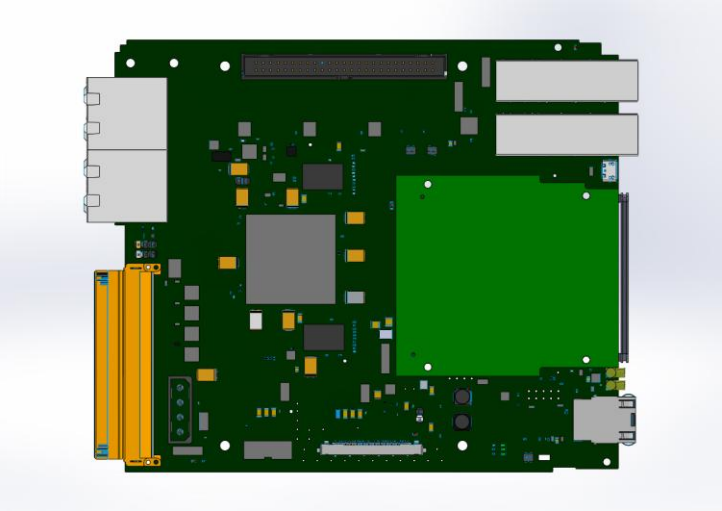


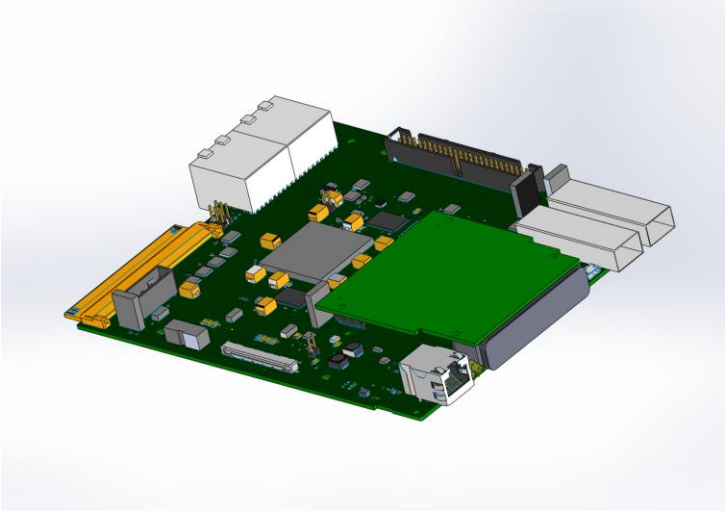
Function of FGPDB

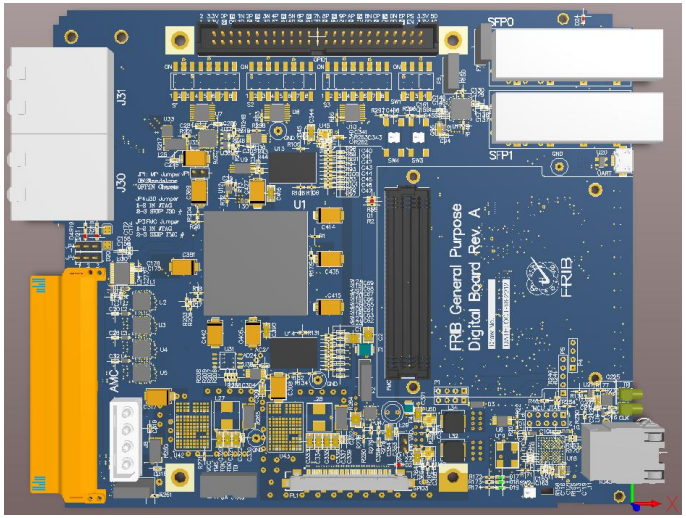


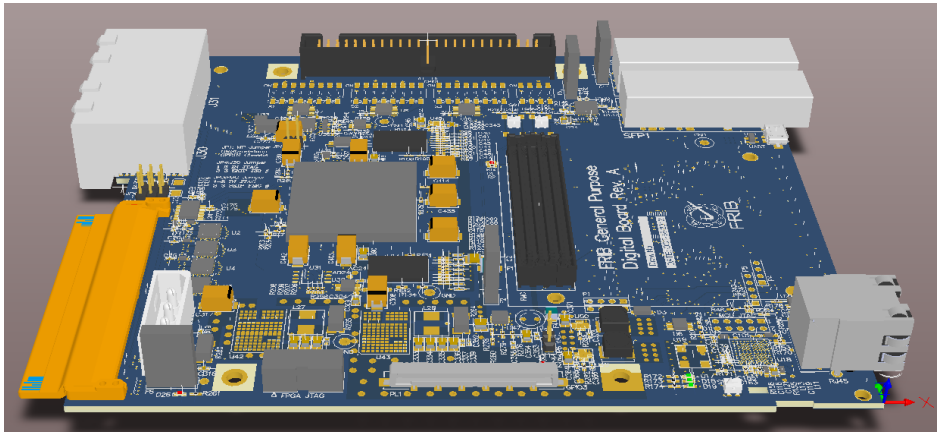
- MTCA.4
- Two SFPs
- Ethernet
- FMC(LPC)
- 8Gb DDR3
- GPIOs
- Update Online
- Support Tree & Multi-circle topology

FGPDB

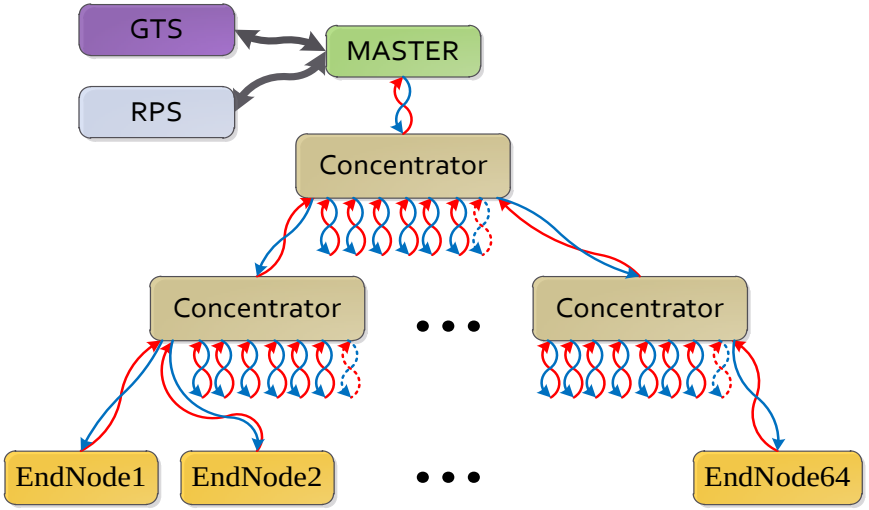





SFP0
SFP1
J31
J30
U1
FRIB General Purpose
Digital Board Rev. A
FRIB

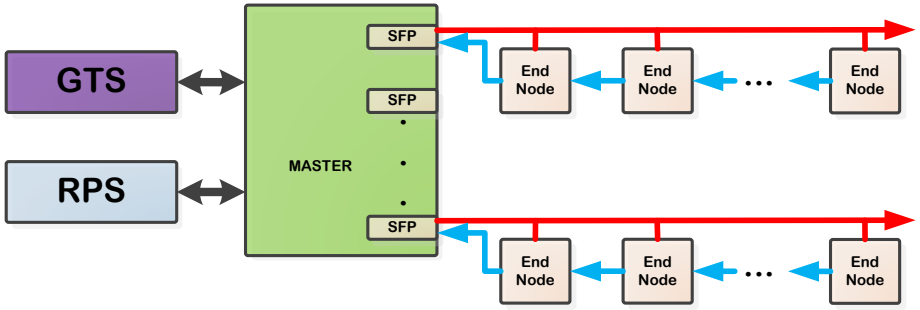

FRIB General Purpose
Digital Board Rev. A
FRIB

FPS Topology



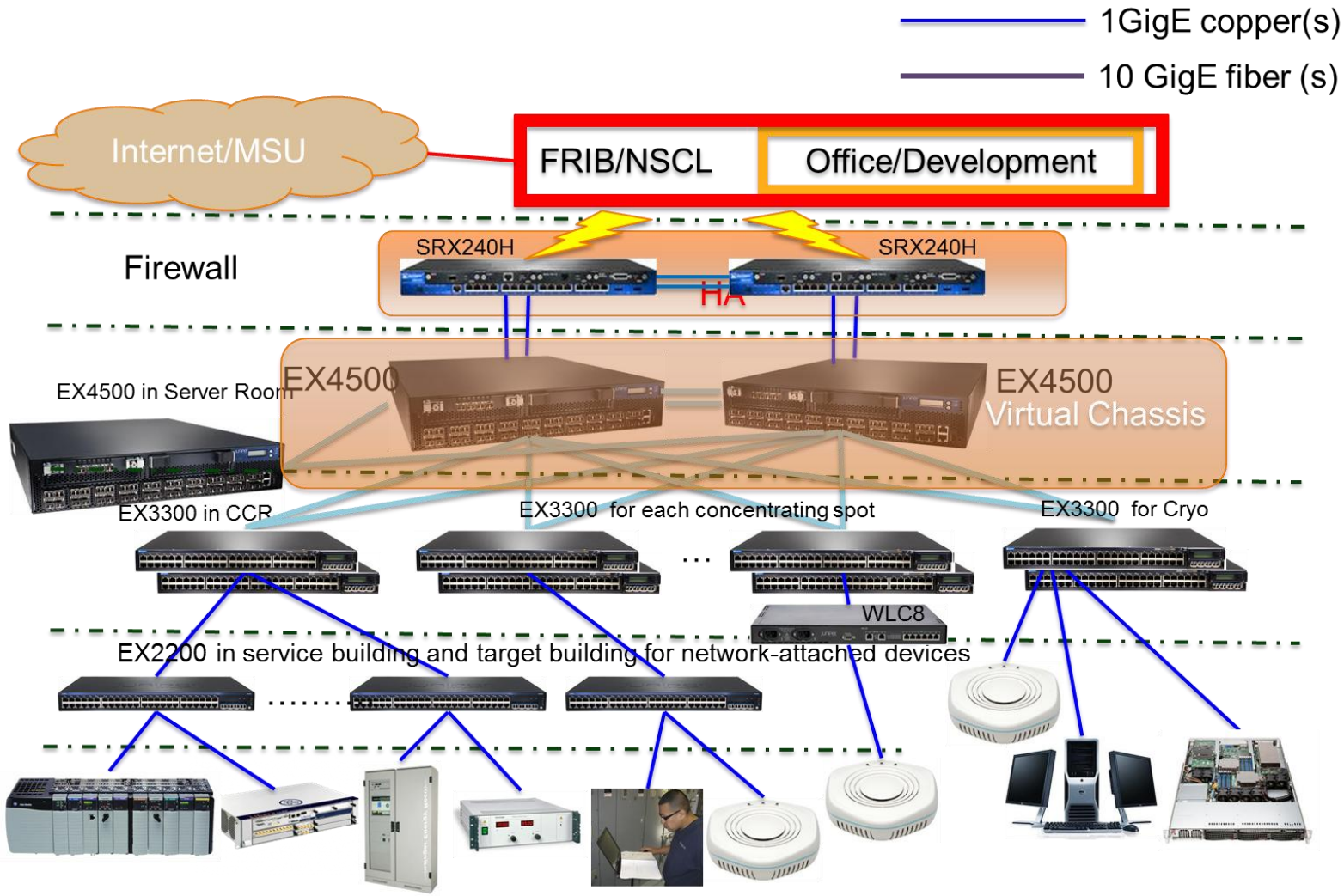
- **Tree topology**
  - Easy to implement
  - Almost same delay for all end nodes
  - Need 120.75MHz reference clock which is higher than system clock
  - Poor message capacity
  - Hard to extend

VS



- **Multi-Circle topology**
  - 80.5MHz Reference clock which is as same as system clock
  - Easy to extend
  - Rich message capacity
  - Different delay for different end node
  - Need a big master

Controls Network



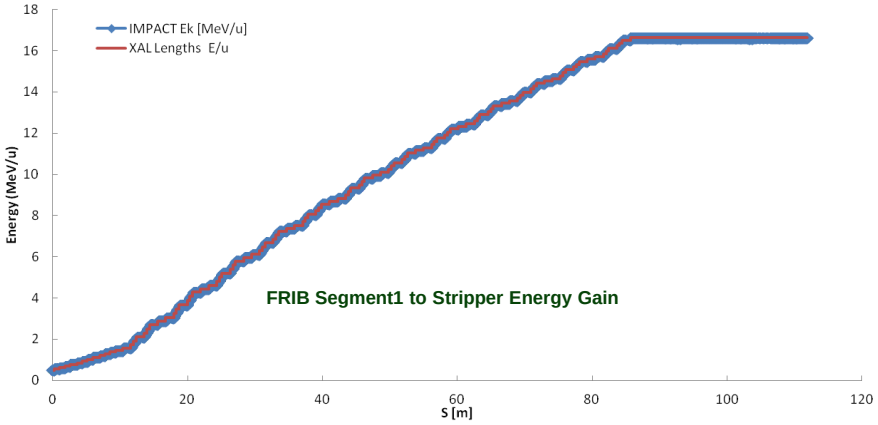
Green-Core Switch, Red-Distribution Switch

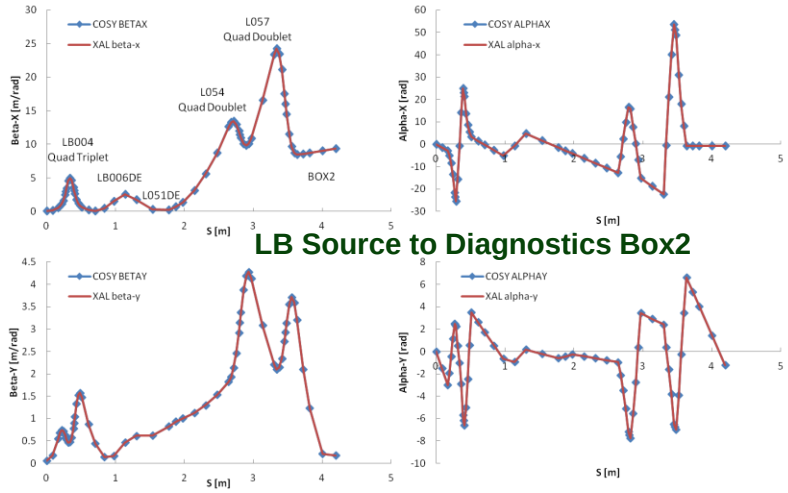
RDB/Apps go well

- E-Traveler production version in field ☺☺☺
- Naming convention in RDB ☺☺☺
- E-log in field ☺☺☺
- Lattice RDB ☺☺
- Stockbook FRIB version beta-release ☺

Technical Status for Physics Applications

- Physics applications deliverables are identified and reviewed
- XAL is adopted and built
- The hardware representation and online model for electrostatic quads are added
- XAL configuration files for FRIB Linac and ReA3 are generated
- Benchmarking is going on against off line modeling tool

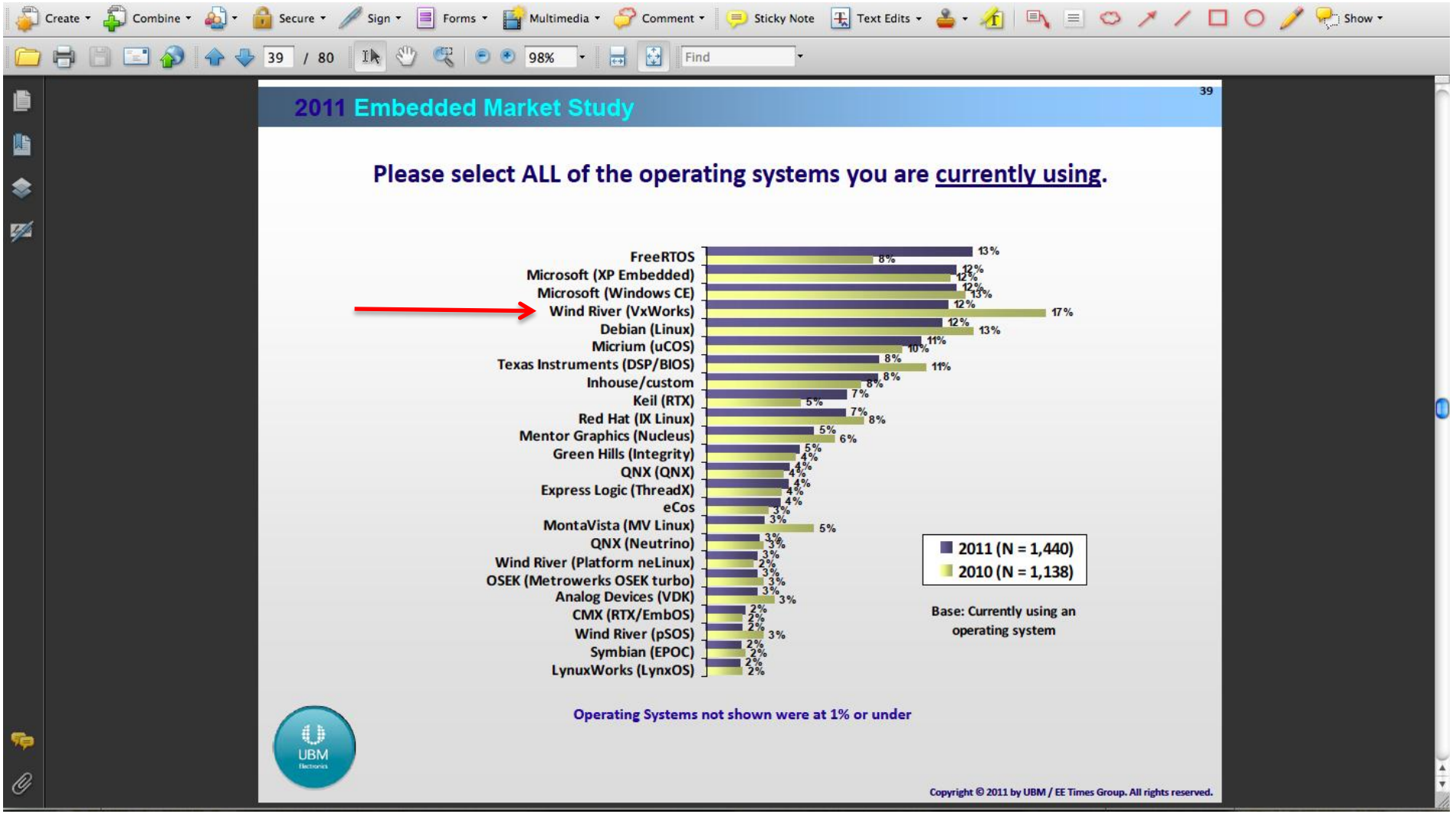




Low Level Control

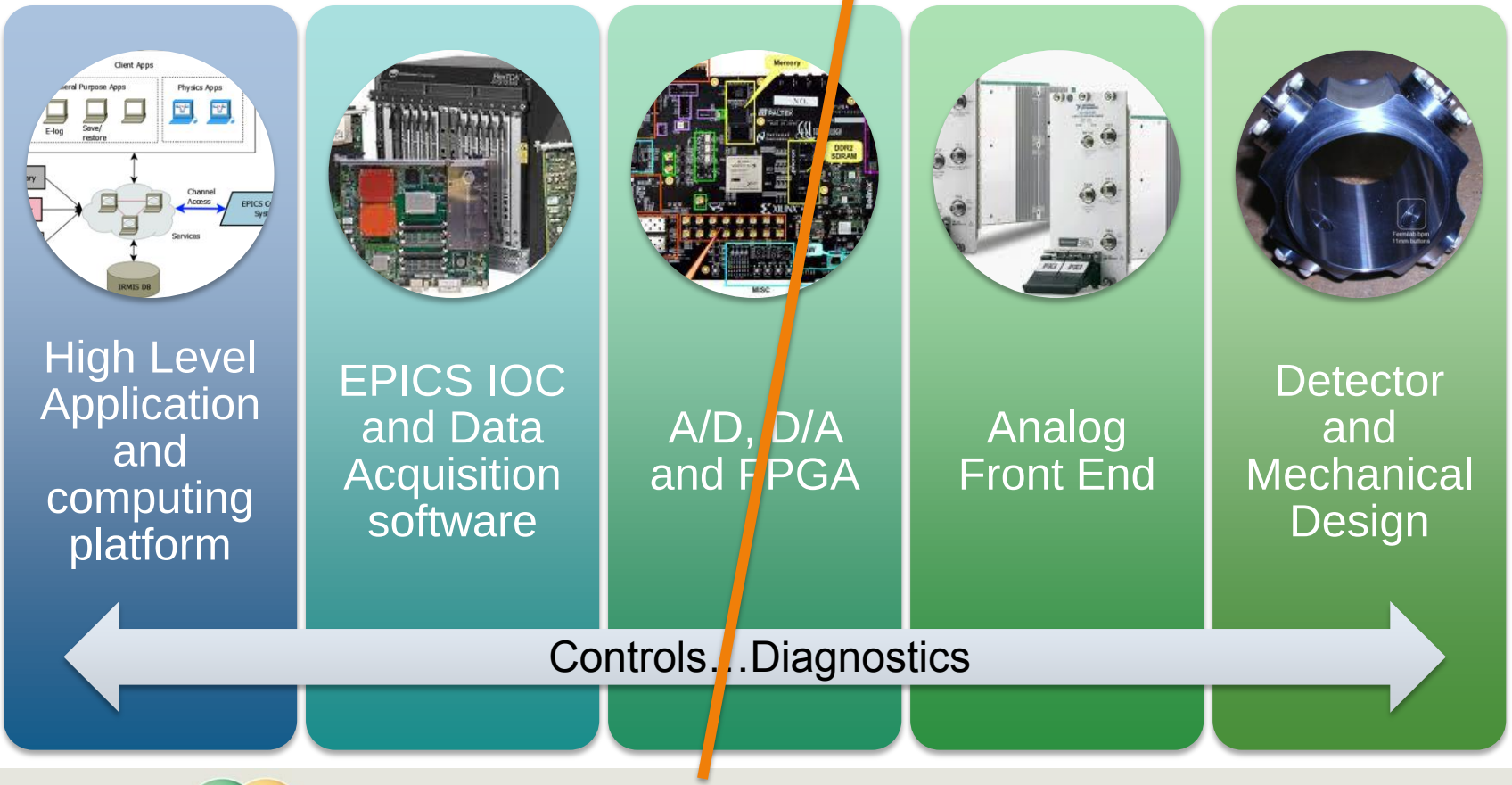
- Allen Bradley PLC
  - Vacuum
  - Cryo
- UDP over Ethernet
  - LLRF
  - PS (To Be Designed)
- Virtualized IOC .vs. Hot-swappable IOC
  - Under evaluation
- Debian/Ubuntu
- What is our RTOS?

RTOS: vxWorks or Linux-RT variants

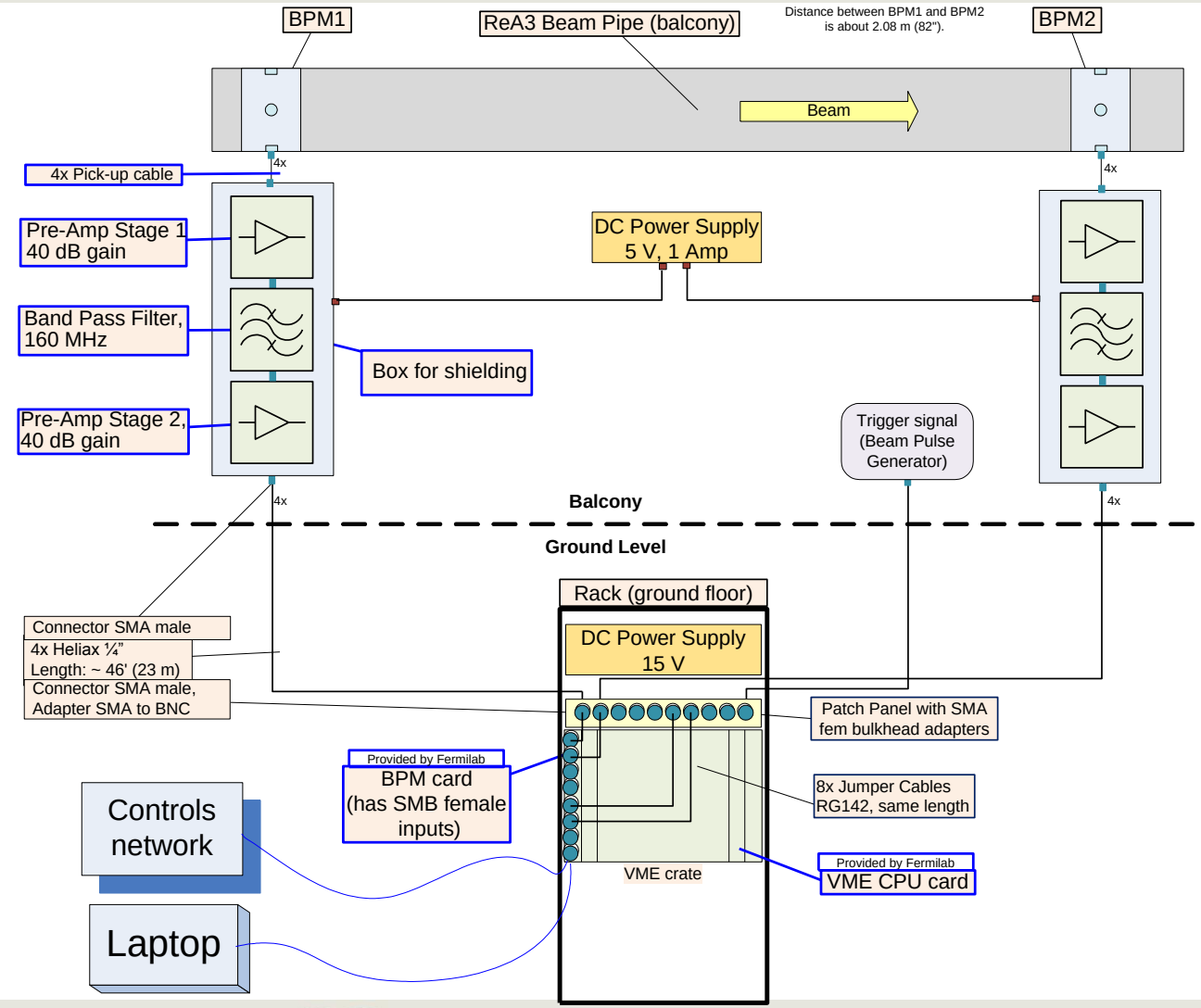


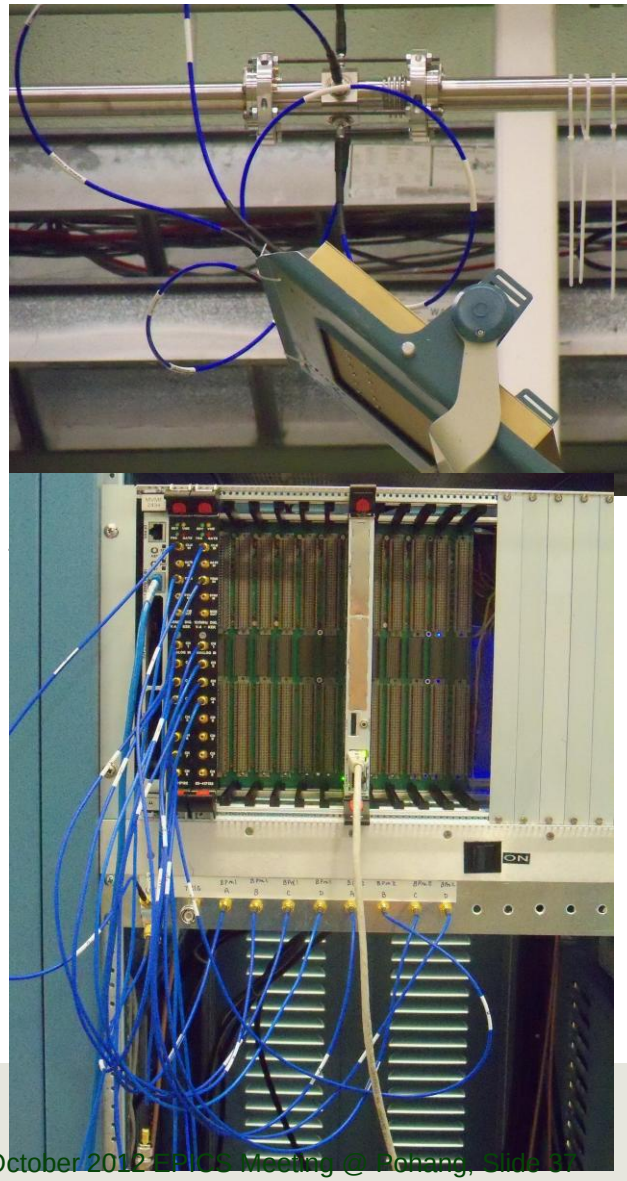
Treaty point

- In general everything from AD/DA,FPGA towards user will be handled by Controls, everything towards the detector will be handled by Diagnostics.



Test Set-Up


BPM1
ReA3 Beam Pipe (balcony)
Distance between BPM1 and BPM2 is about 2.08 m (82").
BPM2
Beam
4x
4x Pick-up cable
Pre-Amp Stage 1
40 dB gain
Band Pass Filter,
160 MHz
Box for shielding
Pre-Amp Stage 2,
40 dB gain
DC Power Supply
5 V, 1 Amp
Trigger signal
(Beam Pulse
Generator)
Balcony
Ground Level
Rack (ground floor)
DC Power Supply
15 V
Connector SMA male
4x Heliax ¼"
Length: ~ 46' (23 m)
Connector SMA male,
Adapter SMA to BNC
Patch Panel with SMA
fem bulkhead adapters
Provided by Fermilab
BPM card
(has SMB female
inputs)
8x Jumper Cables
RG142, same length
Controls
network
Laptop
VME crate
Provided by Fermilab
VME CPU card



PPS

- Access Control
  - AB Guardlogix
  - SIL3 redundant with Compact Guardlogix
- ODH
  - Compact Guardlogix
  - Oxigrad .vs. PureAire
- Requirement tracking and process
  - Enterprise Architect
- Integrate with Conventional Facility
  - BACnet is agreed interface
- Controls role
  - Full Support: LCW
  - Interface with all signals
  - Interface with some signals
  - No interface

Q&A

- Wants to know more about FRIB

pengs@frib.msu.edu

☺Welcome to Michigan!